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NOTES ON THE DESERT TORTOISE (TESTUDO AGASSIZII)

BY

Loye Miller

Professor of Biology, University of California at Los Angeles

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For a period extending over some twenty years, the present writer has been in search of new light upon the life history and habits of the Desert Tortoise, *Testudo agassizii* (Cooper). We are all becoming desert conscious these days, and characteristic forms of life from the desert have an appeal to the popular interest. The habitat is so positive, both in topography and in climate, and so many other species from the region have developed marked adaptations to the austere conditions under which they live, that this strange tortoise has been the object of scrutiny in an effort to learn whether or no it would display any unusual phase of specialization. The result of efforts thus far has been the accumulation of some worth while notes upon the eggs and growth rate, concerning which but little has heretofore been recorded.

Camp (1916, pp. 512-514) has given the most extended account in recent literature. In his account he speaks of finding in the tortoise burrows some broken egg shells presumably of the same species. In another note (1917, p. 85) he briefly describes a single egg sent to him from California, that was laid by a tortoise in captivity and buried, along with three others of the same clutch, in a shallow excavation. About twenty years ago Mr. Wm. Ray Shaw, then of Victorville, California, placed in my hands an unbroken egg which, by exclusion, we identified as the product of this reptile. When eggs were later obtained, a comparison proved the identification correct. The egg was found on the surface of the ground unprotected and, as would be expected, it failed to hatch.

Much journeying over the deserts of Arizona and California has yielded to my own efforts only a dozen or so specimens of the tortoise, but there has been no time during the last twenty-five years that I have not had several of them in my laboratory from the Colorado or the Mojave deserts of California. Only a few sets of eggs have been deposited during this time, although sexual activity has been repeatedly noted. In October of 1916 a full grown female deposited a full set of eggs, the first material of positive identity that had fallen into my hands thus far. Perhaps "fallen into my hands" is an expression of unusual aptness in this case since one of the eggs was actually dropped from the female cloaca into my extended palm. Here at least specific identity seems positively assured.

In the case of my captives, no opportunity to dig burrows was available since the animals roamed about on the deck of a large balcony. There is every reason to believe with Camp (1916, p. 513) that, in nature, the eggs are laid in the protection of burrows after the fashion of some related species. Certainly some such protection would be necessary since exposure to the direct sunlight of the desert, even for a short time would prove fatal to eggs or to young tortoises. An adult specimen which became accidentally overturned upon the exposed deck, perished even in the relatively mild climate of Los Angeles.

The female from which the five eggs here discussed were obtained was picked up in Death Valley, California, late in the spring of 1916, its shell worn smooth by the sand blasts of the desert. The first egg appeared upon the deck roof on October 4 of the same year. The second egg appeared on the 7th, and another on the 8th at 1:30 p. m., followed by the fourth just thirty minutes later. The fifth and final egg was not laid until October 30. There seems then to be no regularity of interval between ovipositions nor were the eggs placed in any particular spot, no two being dropped in the same part of the ninety-foot deck over which the reptile ranged. In all probability the eggs deposited in a natural environment are also placed singly as the animal roams at random across the desert.

The peculiar posture assumed during oviposition was a notable feature of the process and it was practically the same on both occasions when it was observed. The anterior end of the plastron rested upon the deck while the posterior end was raised to the extreme limit of the hind legs. This position gave the egg at least two inches to drop—a distance which proved disastrous in one case, as the egg was cracked by dropping upon the hard surface. Why the animal should assume so grotesque an attitude seems an enigma. It could scarcely be due to a paroxysm of labor since in one case, the anterior limbs remained quite flaccid with no effort apparent. A considerable quantity of watery fluid was extruded with the egg so that a wet spot six inches in diameter was formed on the deck—a spot which dried without leaving appreciable stain.

The egg which was dropped into my hand felt quite warm so the temperature of the animal was at once taken through the cloaca. The resulting temperature of 25 degrees C. was just five degrees above that of the surrounding air. The cloacal sphincter was found to be much relaxed and, upon stimulation with the thermometer tube, the cloaca dilated until the entire atrial chamber became visible through the orifice. Oviposition could easily be accomplished without appreciable effort.

CHARACTERS OF THE EGG

At the moment of deposition the egg is decidedly moist so that the shell appears quite translucent although perfectly hard. It is not like some lizard eggs (*Gecko*), soft at deposition and dependent upon exposure to the air for hardening. This translucence permits of an excellent view of the shell's contents, revealing a small gas bubble some three to four millimeters in diameter that changes position with the rotation of the shell almost as readily as does the bubble in a spirit level. The albumen layer appears to be extremely fluid. After several minutes, owing to the drying of the shell, the bubble becomes less easily visible, yet a careful scrutiny will reveal it almost equally active after five months time. The fact that the bubble shows no appreciable change in size, and that the fluidity of the albumen seems unabated after so great a lapse of time suggests that the marked resistance to drying offered by the shell and the immediately adjacent layers of albumen constitute a great factor of safety for the species in the parching atmosphere of the desert.

The shell itself is extremely thick and hard. An oölogist's drill would make no impression upon it until a small pit was scratched in the surface with a dental tool. Even after a hole was started, drilling was more difficult than with any avian egg that I have met. The texture of the shell appears very coarse and rough to the touch. There are irregular papillations similar to those sometimes seen on the aberrant eggs of domestic fowls. This character is more pronounced in some eggs than in others, and is entirely absent from the specimen presented by Mr. Shaw. Examination with the hand lens shows large pits irregularly disposed and rather far apart. There appears none of that smooth gloss that often gives the finished touch to avian eggs, nor is there a chalky layer comparable to that seen in the eggs of certain water birds. In fact, the whole effect is of an unfinished product from the oölogist's point of view. No pigment of any kind is evident.

One of the features most striking to the oölogist was a marked degree of asymmetry to be noted in all of the eggs. They were of almost equal curvature at the two ends and approached the globular in general shape, thus resembling the eggs of owls. The asymmetry appeared, however, in the inequality of the two shorter diameters. The transverse section is almost as markedly an ellipse as is the longitudinal. This character was about the same in all the specimens studied.

MEASUREMENTS IN MILLIMETERS OF EGGS OF *Testudo agassizii*:

	No. 1	*No. 2*	*No. 3*	*No. 4*
Length	41.6	44.0	43.3	48.7
Maximum transverse diameter . .	36.7	38.0	36.7	39.6
Minimum transverse diameter . .	34.9	36.0	35.5	38.2

The first egg discovered was cracked, presumably by dropping upon the deck from the elevated cloaca of the female. This specimen was opened and the contents removed for study. In the entire mass there appear three degrees of fluidity. There is a highly fluid albumen in which the small gas bubble is enclosed, then there is a very thickly viscid albumen irregularly disposed about the yolk and attached to the shell by a short peduncle. This peduncle is common to all the eggs as may readily be demonstrated by rotating the egg and watching the bubble—there is a definite area around which the bubble always makes a detour. Finally, there is a very tough, pale cream colored yolk within the more viscid albumen.

Ranging with the large female upon the roof deck were several smaller individuals, one of which was plainly a male, but there had been no noticeable sexual activity in this case. If the large female were pregnant, the spermatozoa must have been received while in the desert, not less than four months earlier. Such was quite within the realm of possibility, so an attempt was made to excite development of the eggs. Studies at the Carnegie Desert Laboratory (MacDougal, 1908, p. 78) record 30 degrees C. as the soil temperature on the Tucson desert at a depth of four feet. The cloacal temperature of the female, as stated above, was but five degrees less than this. Thirty degrees was therefore decided upon for the experiment in incubation. Six weeks of constant exposure to a dry heat of this degree failed to show any change whatever.

While I have not actually observed the hatching of the young from the egg, I have twice found a single individual within eighteen to fifty-six inches of the nest containing broken egg shells. These small tortoises have shown the dried yolk sac still exposed at the umbilical area, and their shells were still covered with a peculiar "bloom" that seemed to consist of dried albumen. Their tiny nails were needle-sharp and unworn, so it is felt that they could not have gone far from the nest since hatching. These two specimens, and two others of comparable size, were found about the middle of October in the desert northeast of Barstow. They must have hatched during the late summer at the earliest.

In both cases the nest site pits were very shallow and were located in fine loose sand deposited by the wind. The egg shells were exposed in part, and a few passes of the fingers through the sand brought additional fragments to light. The shell bits were not of such quantity as to suggest more than one egg, and much deeper digging yielded no additional fragments. The very strong suggestion is that eggs are laid but one in a "nest" and this nest is but a few inches deep. From this shallow burial the young one could scramble to the surface and would perhaps bring parts of its shell with it in its struggles.

Miss Eleanor Forsyth, a student in my classes, reported on egg laying observed by her at Needles, California, on June 17, 1923. "The tortoise scratched a hole about three inches deep, doing all the digging with the hind foot, a single egg was deposited and covered by using the hind legs." The temperature of the soil was immediately taken and found to be 96 degrees F. (35 degrees C.). Another egg laying was observed by the same student. The depth was four inches and only the hind foot was used. The nest was in dry sandy soil, and in shade.

THE YOUNG AT HATCHING

The young tortoises but recently emerged measure from 44-47 millimeters (1⅜-1⅝ inches) in length. The eggs measured 42-48 mm. in length, so there is but slight distortion of the carapace by confinement within the egg shell. That there is some distortion is indicated by a more or less crumpled appearance of the plastron which takes some months finally to smooth out.

The little animals are nearly as broad as long, and the dorsiventral diameter is relatively great. They are "chunky," meaty little chaps when first picked up. Both those that were picked up within five feet of the empty egg shells, voided a quantity of water. The water could have come from but one source, *i. e.,* the metabolic changes of the original egg mass. There had been no rain on the desert during the larger part of the year. There was no free moisture in the dry eolian sand drift, and the animals had never taken succulent food. The jaws were virgin fresh and unstained, and there had been no fresh growth of plants since the previous early spring. (It was now October 15.) While being examined the next day, one voided a tiny black pellet of fecal matter, which, tossed out in water, yielded sand grains and a few vegetable fibers. They probably begin feeding in the immediate vicinity upon hatching and like the adults, take any dry vegetable matter available. It certainly appears that free water is not essential to the hatching for some time.

The color of the young varies greatly. The general ground color varies from dull mustard yellow to warm light brown. Darker areas of slaty brown appear on each scale of the carapace in pleasing and symmetrical pattern, but this pattern varies with the various scutes and with different individuals. The nuchal and the caudal plates are both incomplete at birth, both of them being deeply notched and crenulated on the free margin as though they were growing out by granulation. All other scutes including marginals are shaped approximately as in the adult.

Ossification of the carapace is but poorly indicated at hatching and the whole shell remains soft for the three years that I have been able to keep numbered individuals. Specimens picked up on the desert that were larger than my three year olds are still soft. Just when the ossification becomes sufficient for protective armor is not yet known.

The umbilical area is quite incomplete at hatching. The median line between scales is incomplete and the shrivelled stalk of the yolk sac protrudes to some extent, gathering up sand grains while it is soft and retaining them for a period after drying. This distortion of the pattern at the umbilicus persists for at least a year, but seems to correct itself after that time within the second year.

The unworn claws are needle-sharp and there is a sharp pointed prominence on the rostral scale that appears to correspond with the egg tooth of some other reptiles and of birds. This egg tooth is present for a year, but disappears by the second year.

GROWTH RINGS

"Can the age of a tortoise be determined by counting the rings on the scales?" This question is perhaps more often heard than any other regarding these reptiles. Such definite results have been obtained by the study of salmon scales that I was quite optimistic in the matter when I noted that the hatchlings were without growth rings. Very careful study was made of the pattern of the third vertebral scute, particularly in all young specimens obtained. Subsequent study of the same individual after one, two, and three years served greatly to cool my enthusiasm for the method. At birth the whole central area of the scale is finely and uniformly papillated.

At the margin of the scale these papillae abruptly increase in size so that a ridge is produced by the single row of papillae running all around the scale. Outside this ridge the growth area of the scale is located and its subsequent enlargement is accomplished by accretions to the margin. In young animals collected on the desert which had doubled their original size, this central area of papillation was very distinct and its dimensions were those of the hatchling scute. Study of known two year olds and of larger animals of unknown age established the uncertainty of the rings of growth outside the original area. A growth ring might be very well defined on one margin and fade out or else split into two rings on the opposite side of the same scale. An animal might be six years old by count on one scale and but five years old as indicated by another scale, or on the opposite side of the same scale. In still older animals that had been exposed to sand blasts on the desert, the whole central area and an indefinite number of rings may have been entirely obliterated by wear. Theoretically there would be an acceleration of growth during the active season which would result in a thickened ring in the growth area of the scale, followed by a thinner ring formed during quiescence. The rainfall and the temperature cycles on the desert do not necessarily coincide. The tortoises are quite responsive to temperature changes and become quiescent in cold weather. In parts of the reptile's habitat there may be a double rainy season or none at all. The winter rainy season may be unfavorably cold for tortoises and the crop of annual plants might pass while the tortoises were inert. Under animal house conditions, the food supply is continuous and temperature is the dominant influence. This factor is quite regular in its major fluctuations and produces a periodic activity. Even here the growth rings of captive specimens are irregular and do not accurately reflect seasonal activity.

Studies of the Adult

The adult Desert Tortoise wanders freely over the higher parts of the Southern California desert from the Colorado River westward to the Red Rock Cañon area (Ricardo P. O.) north of Mojave. A point four miles off the road from Mojave to Bishop, in the region of Red Rock Cañon, is the most westerly point from which I have actually taken specimens. A point twelve miles north of Amboy is my most northerly collecting station. I have not found it in the low saline desert of the Salton basin, but several were taken in the higher rocky country east and slightly north of Mecca. In Arizona I have taken it as far east as the

Sulfur Spring Valley northeast of Tombstone. In none of these areas is the reptile at all common.

Five days rambling by a party of six people on the hills north of Barstow in most favorable season and territory yielded only four or five animals. The season was April, and green food was abundant both in the broken hills and on the bajadas. Fresh tracks, feces and deserted winter burrows were more common than on any other field trip, yet the animals were not often encountered.

In the fall (October 23) the adults were found holed up for the winter in the Barstow area. A tunnel of oval cross-section is dug into a sandy hillside and the animal goes in to a depth of two or three feet. There seems to be no attempt at filling the tunnel mouth (Plate 10, fig. 1). There is nothing to indicate that an animal returns to a burrow it has once left. Although adults have been extracted from their three-foot tunnels in late October, an active one was found wandering across the road near Providence Mountains on November 26 after a light rain. March to October (or November) seems to represent the period of activity on the high desert. In the Los Angeles area the period for captive animals is much greater. Diurnal activity varies with the temperature of the air. The heat of the day on the desert finds them quiescent under some shrub, and the cool early morning produces a like effect.

Food and Water

While free water may not be essential, these tortoises will drink deeply when water is available. Hatchlings placed in a dish of water will drink 30-60 swallows before raising the head, then take another draught of equal length. The capacity for drinking is almost incredible. A medium sized specimen was placed in a basin after careful weighing. The increase in weight after drinking equaled 41% of the body weight. The experiment was repeated six weeks later, and the increase was 43%. After a shower on the roof deck, my captive animals drink readily from the scuppers, and doubtless the same occurs in the desert on the infrequent occasions when precipitation is sufficient to yield free surface water.

Food of captive tortoises is most varied. Fresh vegetables, apples, melons, bread, cheese, clover, dry leaves, paper—all seem acceptable. On the desert they crop the heads of a composite flower, *Encelia* (*Geraea*) *canescens,* and doubtless would take any other fresh vegetation. Their behavior in captivity suggests that they eat the dried plants during the hotter parts of the year. Such would be necessary if any extended feeding season were to exist since the annual plants have there a most restricted life span. On the other hand, there is little doubt but that long periods without either food or water are a common experience with the species.

Methods of Defense

The excellent armament of tortoises and their power of almost complete retraction into the shell have branded them as almost completely passive in defense. Armor is doubtless their chief reliance. A large German police dog was observed to mouth and paw a specimen for a long time without effect beyond shallow scratches upon its shell. The coyote would find equal difficulty though some injury might be inflicted. The really powerful jaws have never been seen to function in a defensive way. Fighting between rival individuals seems to be limited to ramming with the gular area of the plastron which is developed into an extended and upturned process in the adult male. The animals lurch at one another with this process and endeavor to overturn the rival. Battles of this sort have been watched repeatedly. The inverted foe is seldom left helpless, however, the victor not being wise enough to leave him alone. Possibly his sportsmanship induces him to help his rival up so that they can enjoy another bout. At any rate, psychology seems to play an important part, for one of the pair finally develops an inferiority complex and makes off at a really rapid pace completely unharmed except in spirit. That this fighting is not purely a mating activity was proved by one of the hatchlings—an absurd youngster with the yolk sac still clinging to his plastron. He would lunge at his companion or at an extended finger without the slightest provocation. This reaction was still observable eighteen months after his capture.

Courtship has been observed only in captive animals and the period seems to extend over most of the warmer parts of the year. The male approaches the female with his neck extended and the head bobbing rapidly up and down. The female may retract or may go quietly on feeding or dozing in the sun. The male circles about, nipping clumsily at the edges of the female's shell, a most absurd caricature of the traditional "billing and cooing." Should the female remain retracted, the male may make a lunge at her with his gular "horn," but not with the pugnacity used against a rival.

Mating activity has been observed again and again, but no actual intromission could be detected, and eggs deposited on the roof deck have never shown fertility. It is my personal impression that the animals must be upon fairly loose sand in order to assume the position that would allow complete coition.

GROWTH RATE

The growth rate of these reptiles is in most cases very slow. After a first-hand experience with one of the large Galapagos tortoises which grew from 29 lbs. to 395 lbs. in seven years, I was quite skeptical of the popular reports on the slow rate of growth in chelonians. I am now quite ready to credit the most extravagant of such reports. Observations were made on hatchlings and upon young that were surmised to be about five years old, and in but two cases was growth more than eleven percent per year.

INCREASE IN CARAPACE LENGTH IN YOUNG TORTOISES

Number	*At Capture*	*1st yr.*	*2nd yr.*	*3rd yr.*	*Total*	*Percentage per yr.*
6	44.7 mm.	46.8 mm.	56.3 mm.	72.3 mm.	28.5 mm.	19%
7	43.7	46.6	51.8	......	8.1	9%
11	46.9	70.4	......	......	23.5	50%
12	46.8	48.2	......	......	1.4	3%
8	85.2	93.3	98.5	......	13.3	7.5%
9	68.2	75.2	81.3	......	13.1	9.6%
1	123.0	......	......	130.0	17.0	4.1%
3	50.4	55.3	56.6	......	6.2	6.2%
4	37.9	42.0	......	......	4.1	10.8%
A	106.0	......	110.5	......	4.5	2.1%

The two hatchlings mentioned above, Nos. 11 and 12, were picked up on the same day, and were the same size, both were in the immediate vicinity of their egg shells, they were kept under the same conditions in the same cage, yet No. 11 gained 50% and made three or four growth rings on his scutes while the other grew 3% and made no observable rings. Only one other among the ten young observed made a growth above 11%. This was No. 6 which was kept for three years and averaged 19%, but at the end of that time the shell was still soft. Its length was then 72.3 mm. No. 9, picked up in the wild, measured 68.2 mm. It was still soft in the center of the plastron after two years and after reaching a length of 81.3 mm. No. 8 was picked up in the wild at 85.2 mm. length, and had a firm shell. I am of the opinion that the shell remains soft until the carapace is about 80 mm. in length, and that this length is not attained under four or five years from hatching. My laboratory animals are kept under conditions of food and water more favorable than their native habitat. The temperature extremes are less, but since the temperature at the laboratory is sufficient in summer to prove fatal to an exposed and helpless tortoise, I assume that the growing period at Los Angeles is probably longer than it is on the desert. All factors considered, these observations on growth probably represent a somewhat greater than normal growth rate.

Regeneration and healing of wounds has been observed under laboratory conditions as well as in the wild. One individual of 123 mm. length was brought in from the field with the gular beak of the plastron injured, the corneous scales had been torn off, and the exposed bone was seemingly dead. After three years in captivity the dead area of bone had sloughed off and corneous material had covered the scar. The slough line was not coincident with any suture line, but was more or less oblique. The carapace length had increased but 7 mm. in the three years. Four individuals taken in the wild had suffered severe wounds in the carapace which had been completely repaired resulting in one case in quite noticeable lameness. These wounds were probably produced by falling rocks or by the reptiles themselves rolling down rocky hillsides. The creatures have an insatiable urge to travel, and they work their way up loose rock slides where they have been observed to start a miniature land slide that carried them bumping and tumbling to the bottom of a cañon. In such cases they are again passive in defense, merely retracting into the shell and letting gravity have its way.

DISEASES

Three types of lesion have been noted in the Desert Tortoise. In captivity there have appeared several cases of inflammation of the skin about the head which seems to affect also the membranes of the eye, resulting in entire closure of one or both of the eyes. Treatment of the parts with various antiseptics was not successful and the animals were finally chloroformed. These cases were separated far in point of time and other specimens in the same enclosure did not become infected. Another dermal lesion which may have been causally the same, affected the carapace, resulting in supuration along the growth zones between scutes and eventual sloughing of the scutes. It is not known whether this infection would prove fatal or not, but the possibility of infecting other animals made it seem wise to dispose of such patients. These cases are mentioned as possible control factors in wild animals. One specimen of about 85 mm. length was captured in the desert and appeared to have had some disease of the dorsal scutes which had been corrected, leaving the corneous material less translucent and somewhat crackled in appearance.

Another lesion found in four cases is concretion within the urinary bladder. This condition has been seen in animals from the Barstow area only, where it was first noted in a dried carcass found on the surface of the desert. The specimen was of large size and, when picked up, was seen to contain a spherical concretion so large that it could not be removed without breaking either it or the shell. Two adult tortoises that have died in captivity from no visible cause have been found to contain similar concretions in the bladder, and the stones were discovered only after boiling up the animal for cleaning the skeleton. The specimen found dead on the desert doubtless died from the same cause. No animal actually dissected has contained such concretion, but the allocation of the stone to the urinary cyst is supported by both its shape and its composition.

The shape is roughly globular with a maximum diameter of 60 mm. and a minimum of 50 mm. When broken it shows a concentric structure of chalky material having the color and odor of the renal discharge of normal reptiles. There is enough organic matter contained in it to cause dermestid beetles to atttack and bore into it. In all probability bladder stone constitutes one factor in the mortality rate of adult tortoises.

Enemies

The tortoise after its shell has become hardened probably has pretty effective defense against animal foes except man. I have no evidence that Indians used it for food, but there appears no reason other than religious or ceremonial tabu that would restrain them. These religious restrictions vary much from tribe to tribe and there has been much shifting of Indian population within recent centuries, hence man has probably had something of an influence upon the abundance of the species down to historic times. Since the advent of the white man, whether with pack burro or motor car, the tortoises have fared badly. I have found their bones about prospectors' camps, and have heard many accounts of the relief that tortoise, chuckawalla or even rattlesnake offer from the desert men's menu of beans and salt meat.

At present there are many specimens picked up by the curious motorist, thrown into the back of the car, and carried home to the city dwellers' backyards whence they soon escape and wander out into traffic to perish. One enterprising Italian is reported to supply his Los Angeles restaurant with the essentials of genuine terrapin soup. There is little danger of such becoming an extended enterprise, however, because of the scarcity of the animals, even on the most favorable deserts.

The great danger to the species doubtless lies in the long period of infancy during which the shell is soft. The assumption is made above that five years probably passes before the shell ossifies enough for effective defense against predatory mammals. The coyote or badger would make short work of such a youngster. An American Raven, collected at Barstow, had the skull and feet of a young tortoise in the stomach. A dried shell, 70 mm. long, collected near Barstow had three of the costal plates of the carapace and most of the marginals torn out, and the contents eaten by some predator, apparently a raven. Even with the best of color protection, many young tortoises must fall victim to the beaks of these keen eyed hunters.

No evidence thus far gleaned would suggest more than five eggs per season for an individual female. With such low birth rate and high rate of infant mortality, there must be an enormous longevity of the mature animal in order that the species survive.

Adaptations

There are several characters which are favorable to the survival of this species in its conflict with the austere environment of its desert habitat. Primarily, perhaps, is the low evaporation coefficient of the egg. Five months after deposition the fluidity of the albumen and the size of the "air bubble" in the egg under observation appears unchanged. The resistance to dessication seems to be carried over to the hatchling and to continue perhaps increasingly throughout life. Secondly, the probable ability of the animal to utilize and conserve "metabolized" water produced as an end product from food within the egg mass before hatching and from the food after hatching, is notable. The carbohydrate molecule has a general formula of $Cx(H_2O)y$ where x may sometimes equal y. Respiration would have as its end product x parts of CO_2 gas which requires no water for its elimination, and y parts of water usable as a solvent. Even the products of protein oxidation differ from those of typical mammals. Urea is produced by mammals, while uric acid or its ammonium salt is the corresponding product of birds and reptiles. Urea is soluble and highly toxic, hence must be eliminated at the expense of much solvent water before its concentration becomes too great. Uric acid, on the other hand, is almost insoluble, hence less toxic, and is voided as a whitish solid by the reptile, and a minimum of water is lost. Hence the exclusively vegetable diet with high carbohydrate content is markedly in the animal's favor in the conservation of water.

Again there is an enormous ability to withstand periods of adverse climatic conditions. Either hibernation or aestivation may be resorted to, and the desert being a place of extremes rapidly shifted, the change from one to the other type of adjustment may be rapid. The probably long life span certainly must be of value in the conflict. The rate of development is so slow, and the rate of living is so slow that they must necessarily live a long time to get much living done, so to speak. The birth rate is so low and infant mortality so high that longevity again becomes a necessity. The insatiable urge to travel and the enormous persistence that drives it to repeated attempts and to ultimate triumph (where possible) in overcoming obstacles in its path, carry it over great distances and varied topography.

Where food is sparsely distributed this wanderlust probably serves as a distinct advantage. Power to survive and to repair physical injuries is so marked in many reptiles that the Desert Tortoise cannot be considered specialized in this respect, yet the ability must be often severely taxed in the desert.

Considered altogether, the species constitutes a most fascinating element in the biota of our southwestern deserts, and my own feeling is that it merits our greatest consideration in order that it may continue upon its harmless way.

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EXPLANATION OF PLATES

PLATE 10

Fig. 1. Winter burrow of *Testudo agassizii* on the Mojave Desert near Barstow, California. (Photograph by Carl Chambers)

Fig. 2. Nest cavity of *Testudo agassizii*. Broken shells visible in right center. Mojave Desert near Barstow, California. (Photograph by Carl Chambers)

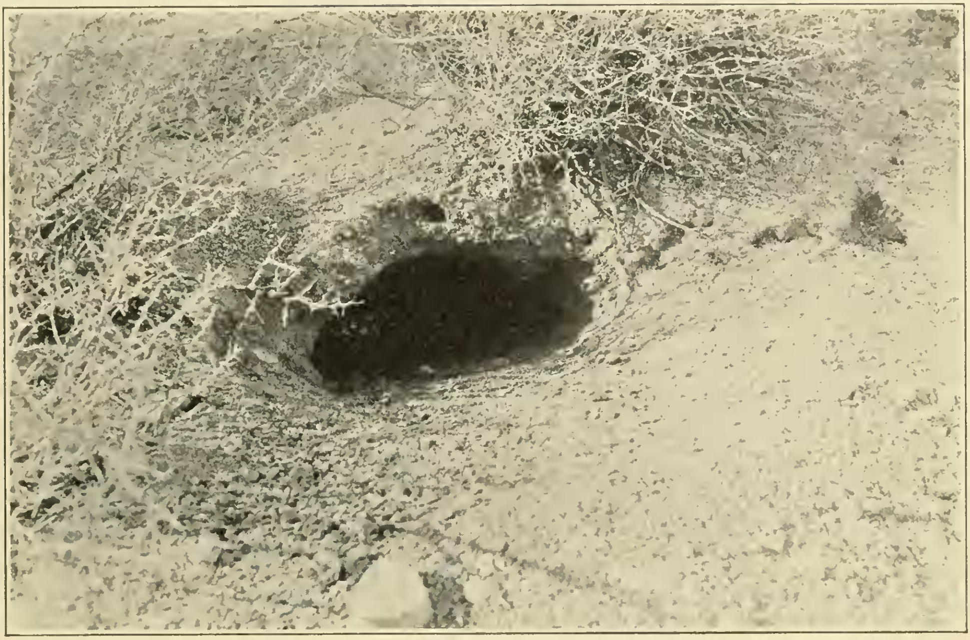

Fig. 1

Fig. 2

PLATE 11

Fig. 1. Young of *Testudo agassizii.* No. 6 is three years old, No. 11 is one year old. They have about the same number of growth rings on the scales. Actual length of the carapace, 72.3 and 70. mm. (Photograph by Loye Miller)

Fig. 2. Young of *Testudo agassizii.* No. 3. This animal is two years old and shows growth ridges on the left side of the vertebral scute No. 3, and three ridges on the right side. Length of carapace, 56.6 mm. (Photograph by Joseph Dixon)